LARVAL AND JUVENILE TUNAS AND SKIPJACKS

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Pacific Oceanic Fishery Investigations

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1/ From Suisan Gakkai Hō, Vol. 4, No. 3, pp. 125-137. April 1926.

2/ From Suisan Gakkai Hō, Vol. 3, No. 2, December 1919.

3/ From Suisan Gakkai Hō, Vol. 4, No. 2, pp. 87-92, December 1924.

An outline of studies of the Plecostei (Tuna and Skipjack) in 1925

The studies of the development and other aspects of the biology of the tunas and the skipjack which have been carried on since 1924 with the assistance of the Keimeikai Foundation have progressed slowly because of the extreme difficulty of obtaining the necessary materials, but with the ardent support of sympathizers we are gradually assembling important specimens and reports. As a result we trust that we are not far from attaining our objectives. The following is a report of the results of our studies during 1925.

Katsuwonidae

Skipjack [Katsuwonus pelamis]

Specimens thought to be larval skipjack were discovered in the plankton collected by the Shōyō Maru off the Satsunan Shichitō [28°-31°N, 129°-131°E] in late May and early June, 1924. Two measure approximately 3 mm, three are approximately 4 mm, and one, excluding the tail, is a little less than 6 mm long. When these fish were compared with larger specimens known with certainty to be larval skipjack, it was thought not unreasonable to identify these specimens as larval skipjack too. Of course it was difficult to study them because of their minute size, but they were stained and examined whole as clarified specimens.

While the posterior part of the spinal cord is bent and the caudal fin is forming, all of the myotomes are evident, but it is not easy to count them accurately. Larval fish can be distinguished as to species by the number of myotomes, the distribution of chromatophores, the spines on the opercular bones, the teeth in the jaws and on the vomer, the shape of the body cavity, and so forth, and when it comes to post-larval specimens the species can be positively identified by an examination of the vertebrae, liver, pyloric caeca, intestines, and so forth.

The specimens approximately 3 mm in length were found in plankton collected southeast of Akuseki I. [29°28'N, 129°36'E] on June 12, 1924. There were two of them, and not much time had passed since they were hatched, for the absorption of the yolk had just been completed (Figure 1). They have many melanophores around the brain, on the opercle, and on the walls of the body cavity, the body cavity is narrow posterior to the head, and the anus opens anterior to the posterior end of the pectoral fins. On one specimen there are chromatophores only on the anterior part of the body, but on the other, as shown in the figure, the posterior part of the body has an upper and a lower row of melanophores. It is doubtful whether these two specimens represent the same species in somewhat different stages of development or whether they belong to two different species. They have not yet developed teeth nor opercular spines.

The juvenile about 4 mm in length was collected early in the summer of 1924 off the Satsunan Shichitō (Figure 2). The head is greatly developed and about ten large sharp teeth appear on each side of both jaws. The vomerine teeth are not yet developed. There are two spines on the surface of the preopercle and five or six spines on its edge. The spines on the posterior edge are long and stout, with the one at the angle being the longest. There is only a shallow round depression at the location of the nasal cavity. The distribution of melanophores is roughly the same as in the specimens described above, but one notable difference is the presence of a large melanophore slightly anterior and ventral to the caudal peduncle. There are also many melanophores around the anterior end of the spinal cord, and the tip of the mandible is blackish. The posterior end of the spinal cord is perfectly straight. It is difficult to tell the number of myotomes because they are not yet fully developed at the posterior end of the body, but there appear to be forty-one of them.

The juvenile specimen which is slightly less than 6 mm long, excluding the caudal fin, has a very large head, occupying about one-half of the total length. The eyes and the mouth are also large and the snout is sharply pointed. Just as in the juveniles described above, the upper jaw is slightly longer than the lower. The posterior edge of the articular bones projects ventrally, and the greatest breadth of the body is at this projection. From this point anteriorly it becomes rapidly narrower and sharper, while posteriorly it tapers more gradually. There is a single nasal pore, and both the upper and lower jaws have thirteen or fourteen teeth on each side. There are four teeth on the palatine and five on the lower pharyngeal bone. The preopercle has three spines on its ventral edge, one at the angle, and three on the posterior edge, of which the one at the angle is the longest There are also two small spines on the surface, and one rather large spine on the surface at the posterior part of the head. The pectoral fins are comparatively large with their posterior ends reaching almost to the origin of the anal. The dorsal is low and not yet differentiated into the first and second dorsals and the finlets, nor is the anterior part of it particularly high. The first spine of the dorsal is somewhat posterior to the anterior edge of the fin membrane and is a little shorter than the second spine. The spines and rays are not yet completely developed. The ventral fins are located between the opercles, and are triangular in shape and pointed posteriorly. The caudal fin is forked. There are melanophores on the walls of the cranial cavity and the body cavity and on the cheeks. Some black coloration is also visible on the upper and lower ends of the snout, but it does not form star-shaped chromatophores. Just as in the larval specimen described above, there is one large chromatophore on the ventral side of the caudal peduncle. The fins are all still colorless. Posterior to the intestine, which is covered with melanophores, there can be seen a large urinary bladder which opens posterior to the anus. The anus opens at a point slightly posterior to the center of the body excluding the caudal fin.

Among the specimens which I have studied, the smallest which I have definitely identified as a skipjack has a total length of 26 mm. It was taken from the stomach of a skipjack at Gonsone [29°47'N, 129°25'E] by Mr. Gisuke Umemoto on April 14, 1924 and was reported on page 92 of Volume 4, Number 2 of this journal as possibly a larval <u>inusawara</u> [Cybium <u>chinense</u> Schlegel] (Figure 4). It was thought at first to be probably a cybiid because of a mistake made in counting the precaudal vertebrae, but by completely removing the muscles from one side and examining the bones of the head and the internal organs it was ascertained that the specimen is a skipjack. In this specimen the breadth of the body has greatly increased so that it is roughly equal to the breadth of the head, and at the same time the body has also become much longer. The anus has moved posteriorly and opens just anterior to the anal fin. The fins are on the center line of the body, and the unpaired ones are all differentiated and have assumed forms resembling those of the adult fish. The opercular spines have degenerated and are no longer conspicuous. The stomach has become a large pointed sac running almost the whole length of the body cavity and pyloric caeca have developed on both the anterior and posterior sides of the duodenum. Furthermore, the presence of inferior foramina in the precaudal vertebrae leaves no doubt that this is a postlarval skipjack. It can be seen from the surface that the postclavicle has developed diagonally from below the pectoral fin, and many melanophores have developed on the walls of the body cavity so that it looks faintly blackish viewed from the outside. The spleen is small and is located to the right of the duodenum. On the top of the head between the eyes there are two pairs of black spots an anterior and a posterior pair, with their edges touching. These spots are where the melanophores in the walls of the cranial cavity show through the flesh. The anterior pair surround the olfactory lobes, and the posterior pair are around the optic lobes. They are more developed than in the earlier specimens, but they become invisible later due to the growth of the muscle tissue and the development of

coloration in the skin over them. There is also some coloration on the snout, around the eyes, and on the cheeks, and there is a good deal of color on the back, along the central line on both sides of the body, and around the vertebral column inside of the body. The upper jaw is longer than the lower jaw, and there are twenty to twenty-five teeth in each. There are sixteen ossicles in the first dorsal and thirteen in the second dorsal with a number of finlets. The anal fin has fourteen and a number of finlets. The first dorsal is higher and darker in color than the second dorsal. Its first three rays are almost equal in length, with the more posterior ones gradually becoming lower. Points of difference between this postlarval form and the adult are the broader body, larger head, eye, and mouth, projecting snout, transparent wall of the cranial cavity, and the presence of an air bladder. Another marked difference is the lack of development of the dark red muscle tissue and its accompanying blood vessels along the sides of the fish.

Juvenile fish 60 - 75 mm long differ from the adults in their narrower breadth, but otherwise they have the general form of the mature skipjack. Scales are already growing in their skin, the pyloric caeca are markedly developed and cover almost the whole of the stomach, the blood vessels of the dark lateral muscle tissue are developed, the dark muscle tissue is beginning to be differentiated from the surrounding tissue, and ten or more teeth can be seen on the palatine bone. The basibranchials are slender, the cerebellum is much smaller than the optic lobes, the spleen is small, the gall bladder is long and slender, and the posterior and dorsal surfaces of the body are covered with a uniform black color not due to chromatophores.

Juveniles 100 mm or more in length show eight or nine transverse stripes of the so-called carangid type or cybiid type (Figure 5). There are four such stripes on the anterior half of the body and four or five on the posterior half. Those on the anterior half are somewhat narrower and closer together than those on the posterior half. The first stripe runs from the base of the first dorsal to the base of the ventral, and the eighth stripe is anterior to the lateral projection or "keel" of the tail. The ninth stripe is not clear but appears to be at the keel. These transverse stripes correspond to what are popularly called the "transverse rings" of the tuna, but in some cases the stripes on the right and left sides of the body run past each other instead of meeting. In the mature skipjack these stripes are sometimes seen on old large fish as they are hauled out of the water. The carangid-type stripes fade out and become invisible on the belly, and at this time the keels begin to develop.

Of these larval and juvenile skipjack, the larval specimens of about 6 mm and less in size were taken in plankton nets, while the postlarval and juvenile specimens were all recovered from the stomachs of skipjack and other surface-dwelling fishes. A boat from Makurazaki [31°16'N, 130°19'E] in Kagoshima Prefecture discovered three juvenile skipjack 100-140 mm in length among the bait sardines which were being scooped up with a dipnet as they swam alongside of the boat after being scattered as chum on the fishing grounds. The fishermen very kindly brought them back and presented them to me for research material. These are very interesting as the first examples of juvenile skipjack taken alive, and a further point of interest is the presence of the carangid type of markings on the two largest specimens.

Genus Auxis

A larval fish about 4 mm long which was taken in a plankton net off Takarajima [29°9'N, 129°13'E] June 8, 1924 (Figure 8) generally resembles the specimens thought to be larval skipjack, however, there are few chromatophores in the cranial cavity and the body cavity, there are four chromatophores on the posterio-ventral part of the body, there are three spines on the surface of the preopercle, and the number of

myotomes is about thirty-eight, all of which characteristics set it apart from them. The tip of the upper jaw is slightly blackish, there is one melanophore on the metencephalon, and the spine at the angle of the preopercle is very long. This specimen is tentatively assigned to the genus Auxis since it resembles a larval fish which was recorded by Ehrenbaum as a presumed larval form of this genus. There is also a possibility that it may be a larval Euthynnus yaito.

Thunnidae

A specimen, the generic and specific identification of which is as yet not clear but which appears to be at any rate a larval form of one of the Thunnidae, was taken in a plankton net while anchored off Takarajima on May 29, 1924. The specimen, which was badly damaged, was about 6 mm long.

Its characteristics are 18+21 vertebrae, a large head, mouth, and eye, black walls to its body cavity, and an anus opening slightly anterior to the middle of the body. The head is about half as long as the body, and the breadth of the head is nearly twice that of the body at the point where the anus is located. The preopercle has three spines on its lower edge, one long spine at the angle, at least one spine on the posterior edge, and three small spines on its surface. The upper and lower jaws have fifteen or sixteen teeth each and there are at least two on the palatine. Melanophores in the cranial and body cavities are not as numerous as in the presumed larval skipjack specimens, and, except as noted above, there is hardly any other coloration visible. The dorsal fin is not high and the first and second dorsals are not yet clearly separated. The rays of the second dorsal and the anal are not yet well developed.

Two postlarval tuna specimens were recovered from the stomach of a skipjack taken on pole and line at Nakasone [28°10'N, 129°15'E] on May 16, 1924. (Figure 6). They are about 34 mm in total length, the body is broad, the head is over half as long as the body without the caudal fin, and the snout is slender and sharp so that at first glance one might think them the larval forms of spearfish or cybiids. The first dorsal is high, the second dorsal and anal are low, and the pectoral, ventral, and caudal fins are well developed. There are long spines on the preopercle, three on the ventral edge, one at the angle, three on the posterior edge, and two on the surface. The spine near the anterior extremity of the ventral edge points forward so that it is roughly at right angles to the spine next to it. There are ten gill-rakers on the ceratobranchial of the first gill arch, but only one is just beginning to appear on the epibranchial. There are 18 vertebrae anterior to the anus and 21 posterior to it. The first vertebra is notably lower than the second and succeeding vertebrae. The epiphyses of the anterior vertebrae are broad, just as in the mature fish and the lateral projections of the caudal vertebrae are somewhat developed. The teeth are of various sizes with about forty in the upper jaw and slightly less than thirty in the lower jaw. There are eight teeth on the palatine, and none are yet visible on the vomer and mesopterygoid. The teeth are well developed on both the upper and lower pharyngeal bones. The basibranchials are just like those of the mature fish. The posterior half of the postclavicle in these larval specimens differs greatly from that of mature thunnids in being altogether flat and straight with the anterior lamellate portion forming a long narrow triangle. The posterior needle-shaped portion is about three times as long as the lamellate part and is roughly uniformly slender throughout its length. The pyloric caeca are pretty well developed, but are shorter than those of the adult fish. The intestine has the bend peculiar to the tunas, and although there are almost no longitudinal folds in the walls of the rectum, they can be seen in other parts of the intestine. The anus opens far posterior to the middle of the body. The gall bladder and the spleen cannot be seen. There is black coloration on the surface of the body,

particularly on the back where about three transverse stripes are also visible. The first dorsal fin is black and the ventral fins are slightly blackish, while the second dorsal, pectorals, anal, and caudal fins are almost colorless. Inside of the body many melanophores can be seen on the walls of the body cavity, around the spinal column, on the gill arches, and on the gill filaments. One of these specimens, which may perhaps be big-eyed tuna [Parathunnus mebachi], had eaten a 16 mm larval fish of another species.

A 36 mm juvenile tuna (Figure 7) was recovered from the stomach of a dolphin which was taken off Gaja I. [29°54'N, 129°33'E] on May 24, 1925. This specimen also cannot be clearly identified as to genus and species. Its form and bodily proportions are roughly the same as those of mature fish, but the eyes and the mouth are slightly larger than in adult specimens. The length of the head is equal to one-third of the body length excluding the caudal fin and to one and one-fourth times the body depth. The length of the snout is approximately equal to the diameter of the eye. About six spines are set closely together at the angle of the preopercle with their basal portions coalescent so that this portion of the bone is produced posteriorly like the preopercle of cybiids. The spines on the surface are obscure. On the first gill arch there are four gill-rakers on the epibranchial, 15 on the ceratobranchial, and one on the hypobranchial. Twelve teeth can be seen on the gill-rakers of the ceratobranchial. There are 24 teeth in the upper jaw, over 30 in the lower jaw, nine on the palatine bone, and some on the pharyngeals. No teeth are visible yet on the vomer and mesopterygoid. The posterior half of the postclavicle in this specimen, as in that described just previously, is almost wholly flat and straight, however, it tapers gradually from the anterior lamellate portion to the posterior needle-shaped part so that the line of demarcation between the two parts is not clear. The coloration of this juvenile is rather dark. The first dorsal is, of course, black, and so is the second dorsal. The pectorals and the caudal are also slightly blackish, but the ventral and anal fins are almost colorless. Particularly notable are the approximately five transverse stripes which appear on the sides of the body, one immediately posterior to the head, two ventral to the first dorsal fin, one between the first and second dorsals, and one ventral to the second dorsal. This specimen differs on various points from the one described just previously, and it is thought to be of a different species. It may perhaps be a yellowfin [Neothunnus macropterus].

Yellowfin Tuna [Neothunnus macropterus]

A juvenile fish 63 mm long (excluding the caudal) and 12 mm deep was recovered from the stomach of a skipjack taken at Gonsone May 26, 1925. It was difficult to study because the skin was missing and the viscera were much damaged, but the vertebral count showed that it was clearly a thunnid, and on the basis of the gill-raker count of 8+(15+7) it was judged to be a yellowfin. There are some fine teeth grouped along the long axis of the vomer and there are six teeth arranged in two rows on the mesopterygoid. The palatine also has some teeth. The anterior half of the postclavicle is 4.05 mm long and 2.30 mm broad; the posterior half is missing. Inferior foramina can be seen in all the vertebrae posterior to the third caudal vertebra.

A specimen which was recovered by Mr. Gisuke Umemoto from the stomach of a skipjack taken at Gogōsone [29°30'N, 129°5'E] May 10, 1924 was reported on page 91 of the preceding number of this journal. From the vertebral count and the presence of inferior foramina in the vertebrae posterior to the second caudal vertebra it appears to be a yellowfin. Besides the upper and lower jaws, there are teeth on the vomer, palatine, and mesopterygoid. There is an air bladder. The anterior half

of the postclavicle in this juvenile specimen is 5.15 mm long and 3.20 mm broad. The posterior half is 9.25 mm long and 2.60 mm broad. The demarcation between the lamellate and needle-shaped portions of the posterior portion is not clear, but it is much longer overall than in mature fish. The total length of the specimen is 100 mm, 90 mm without the caudal, and the depth is about 20 mm.

In the Plecostei as a whole, the preopercle in the larval stage has two rows of spines, one anterior and one posterior, but in the postlarval stage the anterior row disappears and the posterior row generally becomes minute. The mouth is at its largest in the middle period of the larval stage when it extends posterior to the posterior edge of the eye. The snout is also at its longest in this period. The opercle is very narrow during the larval stage, but as the fish approaches the juvenile stage it gradually broadens until its shape resembles that of the mature fish. At the beginning of the juvenile stage serrations begin to develop in the middle of the posteriodorsal edge of the opercle, extending thereafter to the limit of the posterioventral edge. Serrations are also seen on the posterior edge of the subopercle and on the ventral edge of the interopercular. These serrations are a characteristic of the Plecostei from the juvenile stage on, and they appear never to have been seen in the Cybiidae and Scombridae, although some serrations have been noted on the isomaguro [Gymnosarda nuda] but only on the posterior edge of the opercle. Furthermore, the forked shape of the anterior projection of the subopercle in the Cybiidae has never been seen at any stage of development in fishes of the Plecostei.

In Volume 2 (Biology) of the Report of the Danish Oceanographic Expedition to the Mediterranean and Adjacent Seas in 1908-10, which was published December 31, 1924, under the heading "Scombriformes", Ehrenbaum reported the results of research on the material collected during three years by the exploratory vessel "Thor". This paper, with four folding plates and 42 pages of text, is very important, and can be said to be almost the only one dealing with the larval forms of the Plecostei. It is very difficult to obtain larval and juvenile specimens of these fishes and it is even more difficult to determine to what species they belong. Ehrenbaum's classification emphasizing the number and shape of the vertebrae is good, but unfortunately his material was almost all larval forms with no reference to juvenile and mature specimens, and consequently his specific identifications are somewhat unsatisfactory. The paper takes up mackerel, Sarda orientalis, tuna, albacore, skipjack, Euthynnus yaito, and Auxis sp. The author says that he rarely took larval fish over 10 mm and none at all over 15 mm. In effect, during the larval stage the fish are not very active and can be taken in plankton nets, but when they reach the juvenile stage they are very active swimmers and do not get into plankton nets. The small juvenile specimens which I have been able to get were all recovered from the stomachs of fish taken by the Kagoshima Prefecture research vessel Shōyō Maru, and these are few in number. A special net designed to catch juvenile fish has been used, but it has not yet proved effective. It is rather unreasonable to try to pull a fine-meshed net at high speeds. When the mature fish of the Plecostei, which are among the fastest swimmers, are feeding on the juveniles of other kinds of fish, it is not unusual to find twenty or thirty individuals in the stomach of one fish, but when they are feeding on the juveniles of their own kind, only a few specimens at most are found in any one stomach. We are going to try new methods of collecting this year too, but we believe that looking for specimens in the stomachs of skipjack, tuna, and dolphins on the skipjack fishing grounds is still a convenient method.

I am seeking particularly larval forms of skipjack and tuna about one inch in length, and I request the assistance of any of my readers who may have opportunities to obtain such specimens.

I would like to take this opportunity to report that the 17 mm and 8 - 10 mm specimens which were described by Lütken in 1880 as postlarval albacore, and the figures of which I had reproduced in this journal with the observation that the marked shortness of the first two or three spines of the first dorsal made it difficult to consider them as belonging to the Plecostei, have been reexamined by Ehrenbaum, who reports that the shortness of the spines is due to their having been broken and that the specimens are unquestionably tunas.

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Explanation of Figures

1 - 3 larval skipjack?

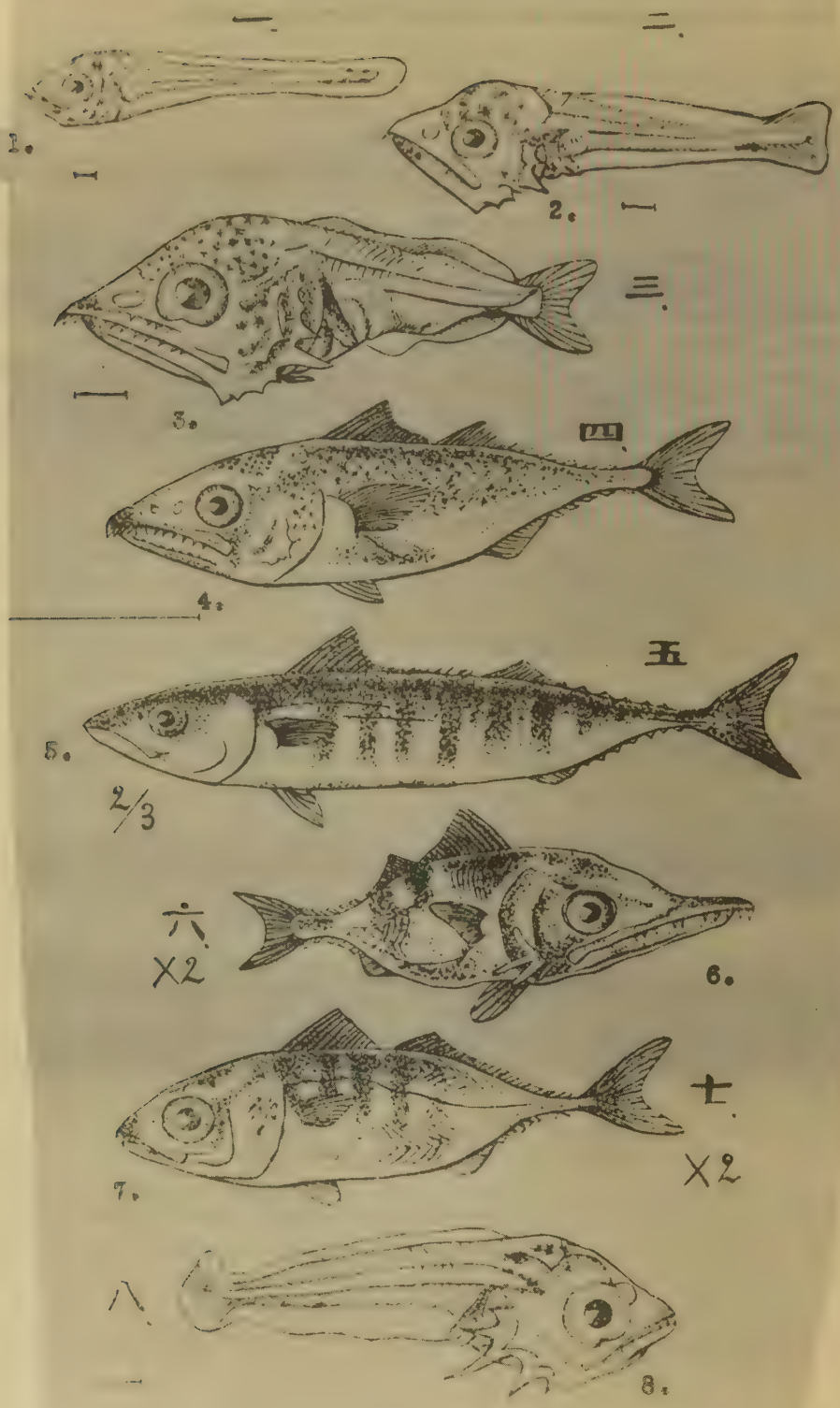
4 late juvenile skipjack

5 juvenile skipjack

6 postlarval thunnid, big-eyed tuna?

7 larval thunnid, yellowfin?

8 larval Auxis?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The larval and juvenile stages of the Plecostei

The Plecostei, that is the tunas and bonitos, differ greatly in their structure from the Teleostomi. They occupy the highest position among the fishes, and their flesh is similar to that of the higher vertebrates. Furthermore these fishes are important economically and their fisheries are expected to expand greatly in the future. Therefore the investigation of the embryology and development of these fishes is necessary from the point of view of both science and industry. It appears that all of these fishes hatch in pelagic waters and even the larval and juvenile specimens are unfortunately not easy to come by. This past summer I announced through the local government offices and fisheries experiment stations, which have the greatest opportunity to obtain these juvenile fish, that I would pay from one to five yen apiece for specimens under 3.6 inches in length which fishermen might send to the Agriculture Department of the University. As a result I was informed that there were prospects of getting such material from the Okinawa Prefecture Fisheries School, and the Yashakumon dried skipjack stick factory of the Taiwan Fisheries Company at Keelung kindly sent me 4.8-inch and 7.2-inch specimens of Euthynnus yaito which were taken in August and September in the sardine set nets at the mouth of Keelung Harbor. Mr. Yokoya was sent to the Bonin Is. by the University to test a large surface trawl with the object of collecting juveniles, and although this experiment has not yet been completely successful, with such attention being given to the problem in all areas I trust that it will not be long before suitable material can be obtained.

As a basis on which to conduct the search for juvenile Plecostei I wish to summarize here the past knowledge concerning them. In 1880 the Danish scholar Lütken published a work on the marine fishes of the Atlantic in which he recorded one specimen about .72 inch long which was found in surface trawl collections made by the "Galatheas" June 3, 1846. He identified it as probably being an albacore, and gave the same identification for a number of even smaller specimens about .36 inch long which resembled it. He published figures of the large specimen and one of the small ones. This is perhaps the earliest published record of juvenile Plecostei. (Figures 1 and 2).

Later Günther studied the collections made by the "Challenger" and in his report published in 1889 he recorded juvenile specimens about .72 inch long which were taken by surface trawl between Japan and the Admiralty Is. (south of the Carolines) between March and April, 1875. He identified these as being probably Euthynnus yaito and published a figure of one of them. (Figure 3).

Lütken identified his specimens as tunas solely because he thought that they resembled tunas in outward appearance, and unfortunately there is no conclusive evidence sufficient to guarantee the correctness of this identification. In both of Lütken's juveniles the first two spines of the dorsal are short and the third spine is the longest. The first dorsal, with the exception of a small portion at its posterior end, is black, the mouth is wide, the teeth are sharp, and the posterior end of the maxillary extends as far as the center of the eye. According to Günther the coloration of the fins as shown in the figures makes it more likely that these specimens are cybiids. I think, on the basis of the shortness of the anterior spines, that they are not tunas nor bonitos. Furthermore, the curves on the surfaces of the myotomes are simple and their angles are obtuse, which makes me think that they are probably not cybiids either.

The juvenile which Günther considered to be a Euthynnus yaito, according to the figure, can be deemed to be a plecostean fish since the first spine is the longest of the first dorsal, the caudal peduncle is flat, and there are keels on both sides of it, however, the whole body is said to be covered with fine scales and consequently it cannot be a katsuwonid. It may perhaps be a juvenile thunnid.

In general in determining whether or not a specimen is a plecostean juvenile and what species it belongs to, the most accurate method is to examine the number of vertebrae and the blood vessels on the sides of the body, but past studies have failed to include these important points.

On March 10, 1875 the "Challenger" left the Admiralty Is. and headed north along the west side of the Marianas and the Bonins toward Tōkyō Wan, arriving at Yokohama on the evening of April 11. The juvenile fish under consideration were collected somewhere along the way, but the report gives no more detailed information about the place and time.

Assuming that these specimens are the young of tunas which grow up in the South Seas, it is thought that they must be either albacore, big-eyed tuna [Parathunnus mebachi], or yellowfin tuna [Neothunnus macropterus]. Because of the paucity of data, however, it is difficult to tell what species it might be that spawns before March. According to the figure of this fish there are several spines at the angle of the preopercle, the pectorals are comparatively large and according to the description, the whole body is bright silver with the anterior end of the first dorsal dusky.

The smallest plecostean juvenile which I have seen is a Euthynnus yaito about 4.8 inches in total length. It differs from mature fish in having a slenderer body and caudal fin, shorter pectorals, a larger eye, markings which run transversely across the body from the back to the belly on every second myotome, and no spots on the pectoral region.

Specimens of E. yaito which have grown to a length of 7.2 inches are very similar to the adult fish, with broad body and caudal fin, spots on the pectoral region, and transverse markings which run at a slant from the back toward the belly above the lateral line.

The next smallest specimen is a skipjack [Katsuwonus pelamis] about 7.8 inches long collected in Okinawa Prefecture in August 1916 and forwarded to me by Mr. Koichi Kamei, the principal of the Prefectural Fisheries School. It differs from the adult in the marked slenderness of the body and the presence of only two faint longitudinal stripes on the belly. Two or three dark slanting lines are visible on the posterior part of the back just as in the adult.

The smallest thunnid which I have seen is a black tuna [Thunnus orientalis] measuring about 8.4 inches in total length. The body is very slender, the eye is comparatively large, and there are numerous transverse markings running from the back toward the belly. As some of these fish grow, the markings on the belly become dotted lines which then become restricted only to the lower part of the belly where they gradually come to slant posteriorly, and the dorsal fins become black.

Black tuna from 8.4 inches to one foot in length are taken from July to September within 2 or 3 miles of the coast everywhere in Japan, and it is said that even smaller fish are taken from time to time. It is hoped that some specimens of such fish can be obtained. Black tuna increase greatly in breadth as they grow to more than 8.4 inches in length.

In general the young plecostean fishes collected in Japan do not show any points of difference from the adults, and most of the peculiarities of the arteries of the dark lateral muscle tissue can be observed from the outside. For this reason, when a slightly detailed examination is made, it is easy to ascertain to which species the fish belongs.

The so-called "keels" which project on both sides of the tail are not conspicuous in the cybiids, and they are also low in the bonitos and tunas.

When we look at the interesting markings of the Plecostei, we find that in the species of Katsuwonidae which have slanting markings on their backs the young fish have transverse markings of the so-called transverse ring type. The part of these markings which lies below the lateral line disappears later leaving the so-called cloud pattern. On the other hand, the black tuna and yellowfin, which also have transverse rings when young, lose the markings on their backs as they grow larger, and only gray markings are left on the anterior part of the belly.

On katsuwonids such as the skipjack, which have longitudinal markings, it seems that only longitudinal stripes appear from the very beginning. Furthermore, among the thunnids there are some like the albacore and the koshinaga [Neothunnus rarus (Kishinouye)], which probably never have transverse rings but only longitudinal markings on the belly.

When one looks at juvenile hagatsuo [Sarda orientalis], the fish which most closely resembles the Plecostei, at about 9.6 inches in length, one finds that they have transverse rings which are broader than those of the katsuwonids as well as several slanting lines on the dorsal portion of the body. Later these slanting lines persist while the transverse rings disappear.

Observations on the skipjack fishing grounds

Last year (1923) I was able to assemble and publish various items concerning the tunas and bonitos, which I have been studying for the past ten years or more. This year, with the assistance of the Keimeikai Foundation, I have continued these studies. In May I made a field trip to Kagoshima Prefecture and, through the kindness of the Prefectural Fisheries Experiment Station, I was able to travel aboard the research vessel Shōyō Maru to the islands of Kuchinoshima, Nakanoshima, Kogaja, Gaja, Suwase, Taira, Akuseki, Kotakara, Takara, and Yokoate, which lie between Yakushima [30°20'N, 130°30'E] and Amami Ōshima [28°15'N, 129°20'E], and saw the actual conditions on the skipjack grounds of the area, which extend for about 100 miles from north to south and about 60 miles from east to west. Since the materials which I obtained at that time and those which were previously collected for me by Mr. Gisuke Umemoto aboard the same vessel are important to the knowledge of the life histories of the skipjack and other pelagic fishes, I am going to gradually assemble and make available these data, beginning with those parts the study of which has already been completed.

Skipjack [Katsuwonus pelamis]

I took along with me a specially constructed net for collecting larval and juvenile fish, but there were few opportunities to try it and I was regrettably unable to learn whether or not it is suitable. Fish eggs and larval fishes were collected with a small net, but it is not known to what species these belong. This is because I have never seen ripe skipjack eggs and do not know the characteristics of newly-hatched larval skipjack.

Among the material which I obtained the specimens which can be recognized with certainty to be skipjack were recovered from the bellies of the parent skipjack and yellowfin (most of them being juveniles). These fish congregated around reefs with depths of over 50 meters and water temperatures of about 25° and fed on the young of various pelagic fishes, called collectively komajako by the fishermen, which are abundant in such areas at that season. It is thought that these young fishes, and particularly the young skipjack, are most plentiful in the stomachs in the forenoon. There are quite a few fresh specimens in the komajako if it is removed from the stomachs immediately after the fish are captured. If they remain for long in the stomachs, the skin is digested and the surface of the flesh also begins to be digested, but even in such cases it is possible to distinguish tunas and bonitos from other fishes by the appearance of the dark red tissue along the sides, and identification is even more certain if the flesh is removed so that the vertebral column can be seen. Five or six juvenile skipjack are sometimes found in one fish, and judging from this it appears that these juveniles are present in some abundance, however, when this is compared with the appearance of 20 or 30 juveniles of Prionurus spp. in one stomach, it is indeed a very small number. Probably this is because the Prionurus are slow in their movements while the skipjack are quick.

The following is a list of the juvenile skipjack which have been collected.

Date	Length	Location
May 16	58 mm	Nakasone [28°10'N, 129°15'E]
May 19	60 mm	Nakanoshima [29°51'N, 129°52'E]
May 19	80 mm	Nakanoshima
May 21	63 mm	Gonsone [29°47'N, 129°25'E]
May 21	83 mm	Gonsone
May 21	85 mm	Gonsone
early June	120 mm	

Date	Length	Location
early June	153 mm	
July 1923	105 mm	
July 1923	125 mm	
August 1923	210 mm	

This list indicates that the growth of the skipjack is extraordinarily fast, however, it does not differ too much from the rates of growth of the black tuna [Thunnus orientalis] and the Cybiidae. It appears that the fish grow more than 40 mm per month, and figuring at that rate it is thought that the first skipjack were hatched in March. Since fish with enlarged ovaries are also seen around July and August, it appears that the spawning season of the skipjack continues over quite a long period of time.

The juvenile skipjack listed above are blue-black on the dorsal surfaces and their bellies are silvery without any visible markings. On specimens 200 mm or more in length the stripes begin to be faintly visible. The shape of the fish varies considerably as between individuals, but generally the juvenile fish are slender. The characteristics of the skeletal parts and the viscera (particularly the liver and the pyloric caeca) in these juveniles are the same as those seen in mature fish, so if these points are examined, the species can be clearly distinguished without any danger of confusion.

In small juvenile skipjack the boundary between the rectum and the rest of the intestine is not clear, and the walls are thin in all parts of the intestine. The juveniles of Euthynnus yaito and the various species of Auxis, on the other hand, have a thick-walled rectum, while the other parts of the intestine are so thin-walled that the contents can be seen through them. The three lobes of the liver are all slender and thin and roughly of equal length.

The food of the juvenile fish consists mainly of copepods, amphipods, and other larval and small-sized crustaceans. These animals float close to the surface of the ocean between dusk and dawn, and it seems likely that the juvenile skipjack follow the movements of these crustaceans. As the juveniles grow they gradually come to eat larger and larger crustaceans. Juveniles 110 mm long feed on Typhis (an amphipod) about 5 mm in length, and cases have been seen in which juveniles 130 mm long fed on young scyllarids about 30 mm in length.

Euthynnus yaito

The smallest plecostean juvenile which I have been able to obtain is an individual of this species 36 mm long. It was recovered by Mr. Umemoto from the stomach of a skipjack taken at Gonsone on April 14 of this year. The body of this specimen is rather broad and the mouth is rather large, characteristics which distinguish it from juvenile skipjack, however, without examining the viscera and the skeleton it would be easy to confuse the two. The markings are not visible and the color of the back is pale.

Surprisingly enough this little fish had eaten one unidentified juvenile fish 10 mm long and two others about 6 mm long. Furthermore some black material was seen in the intestine, but since it had not retained any particular shape it was difficult to tell what it was. The walls of the rectum were thicker than those of the rest of the intestine. The right lobe of the liver was slender and long, reaching to the rectum, and the middle lobe was broad.

Auxis maru

Juveniles of this species are obtained from time to time in the same manner as the juvenile skipjack, which they closely resemble in their development. These fish can easily be distinguished from their outward appearance alone by the thinner body and the discontinuity of the dorsals. As examination of the viscera shows that the right lobe of the liver is thick and long, reaching to the anus, and the walls of the rectum are thick. Their food, like that of the skipjack, consists of larval copepods and decapods.

Date	Length	Location
May	75 mm	
May 21	80 mm (2 fish)	Gonsone
June 1923	145 mm	
July 1923	145 mm	

Yellowfin tuna ? [Neothunnus macropterus]

One juvenile thunnid 100 mm long was collected by Mr. Umemoto from the stomach of a skipjack taken at Gogōsone [29°30'N, 129°5'E] on May 10. The skin and viscera had been damaged. It is broader than juvenile bonitos, the caudal fin is large, and the first dorsal is high. From the large size of the eye it might perhaps be thought to be a juvenile big-eyed tuna [Parathunnus mebachi], but it is perhaps better to consider it a juvenile of the yellowfin tuna, which are abundant in the vicinity. A small air bladder can be seen on the dorsal surface of the body cavity. At some time in the future when a large number of specimens of this type come to hand, it will probably be possible to find out to what species these juveniles belong. No big-eyed tuna or yellowfin with ripe eggs have been seen hitherto, and it is not known when they spawn or at what size they mature, but this juvenile was apparently hatched around March or April.

The above information all concerns plecostean fishes.

Inusawara ? [Cybium chinense]

A 26 mm juvenile which Mr. Umemoto took from the stomach of a skipjack at Gonsone on April 14 was thought to be a plecostean, but from the large size of the mouth and the fact that the maxillary projects slightly past the posterior edge of the eye it is judged to be a cybiid. The head is large, occupying more than one-third of the total length, and both lobes of the caudal fin are broad and somewhat rounded in outline, although they appear small in comparison with the breadth of the body. The identification as an inusawara is based on there being 18 vertebrae anterior to the anus.

Gurukun [Rastrelliger chrysozonus] (reported in Vol. 1 under the name agifurakiya)

Specimens from 20 to 37 mm in length were recovered from the stomachs of skipjack taken at Gonsone on April 14. The body is slender and the fish closely resemble young mackerel. It appears that they grow to about 150 mm by the latter part of May. This rate of growth is very rapid compared to that of the European mackerel, which is said to grow on the average 10 mm per month.

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